

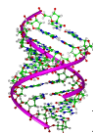
A BENCH STUDY ON PESTICIDE IMPACTED SOIL COLLECTED FROM THE WOOLFOLK CHEMICAL SITE

Analyses performed by US EPA Region IV Lab., Athens, Georgia

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5/11/2012

A collaborative study to determine the reductive capabilities of various Factor based formulations on pesticides and pesticide congeners in soils collected from the Woolfolk Chemical site at Ft Valley Georgia.

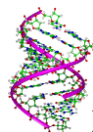


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BioTech Restorations, LLC (BTR) was contacted by Tim Bricker from Tetra Tech and Terry Chuhay from JM Waller Co., to determine if their bioremediation technology could be successfully used to clean up the pesticide impacted soil at the Woolfolk Chemical Site in Georgia.

In order to demonstrate the efficacy of their Factor Treatment in the bioremediation process a bench study was initiated by BTR to determine which Factor(s) brought about the most reduction in the pesticide concentrations. Since toxaphene was one of the contaminants, the EPA was also interested in finding out if the Factor Treatment could reduce the concentration of the toxaphene congeners (breakdown products of toxaphene), which the EPA considers more toxic than toxaphene, and which pose a greater threat to human and animal health.

Using an immuno-assay procedure to measure the concentration of the pesticides in the field, Tim Bricker and Terry Chuhay collected approximately 3Kg of soil showing contamination levels of at least 4ppm for the main contaminants (alpha chlordane, dieldrin, gamma chlordane and toxaphene). This contaminated soil was placed in a 5Kg bucket and shipped overnight to BTR's Lab in Clemson, SC. On receipt of the bucket the contaminated soil from the site was well mixed, and a sample of soil was sent to McCampbell Lab in CA to obtain a soil profile. From the remaining well-mixed, contaminated soil an equal quantity of soil was placed in six glass containers, labeled WFC1 through WFC6. From each container 100g of soil were placed in separate glass sample bottles provided by JM Waller and following their instructions for packing and shipping, they were then shipped on ice overnight to the US EPA Region 4 Lab in Athens, GA to determine the initial concentrations of the pesticides. Nothing further was added to container WFC1 which served as the control for the study. Based on the results of the soil profile various amendments were added to each of the experimental containers (WFC2 to WFC6). Different Factors and water were added to these experimental containers, and the soil was well mixed. The containers were loosely covered with aluminum foil to maintain aerobic conditions, and to prevent the surface soil from drying out. The soil was mixed weekly and checked for moisture content. After six, 10 and 16 weeks of treatment samples of soil from each container were sent to the US EPA Region 4 Lab in Athens, GA for analysis of the pesticide and toxaphene congener concentrations.



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The results of the soil profile are shown in Table 1.

Table 1: Soil profile for Woolfolk Chemical soils (sampled on August 25, 2011)

| Parameter | Data on a dry weight basis |
|---------------------------------|--|
| Ammonia-N | 1.9 mg/Kg |
| Nitrate-N | Not Detected (ND); (Nitrate conc. ND<46 mg/Kg) |
| Total P | 82 mg/Kg |
| % moisture | 1.58 % |
| TOC (Total Organic Carbon) | 6,200 mg/Kg |
| HPC (Heterotrophic Plate Count) | 130,000 / gram |
| Fe | 3,100 mg/Kg |
| As | 5.2 mg/Kg |
| pH | 6.41 |

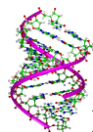
The data for the initial pesticide concentrations are shown in Table 2.

Table 2: Initial pesticide concentrations at week zero (sampled on October 27, 2011)

| Sample | Alpha Chlordane mg/Kg | Dieldrin mg/Kg | Gamma Chlordane mg/Kg | Methoxychlor mg/Kg | Toxaphene mg/Kg |
|--------|-----------------------|----------------|-----------------------|--------------------|-----------------|
| WFC1-0 | 4.9 | 1.2 | 6.5 | 1.3 | 4.8 |
| WFC2-0 | 4.4 | 1.2 | 5.9 | 1.3 | 4.7 |
| WFC3-0 | 5.9 | 1.2 | 7.9 | 1.4 | 4.6 |
| WFC4-0 | 4.5 | 1.0 | 6.0 | 1.4 | 4.3 |
| WFC5-0 | 5.6 | 1.2 | 7.5 | 1.4 | 5.0 |
| WFC6-0 | 5.3 | 1.0 | 7.1 | 1.4 | 4.7 |

All other pesticides were present at < 0.9 mg/Kg

Since at this time nothing extra has been added to the soils in each container, the values for each pesticide represents six replicates of that pesticide present in the soil; i.e., alpha chlordane ranged from 4.4 to 5.9 ppm with an average of **5.1ppm**; dieldrin ranged from 1.0 to 1.2 ppm with an average of **1.1ppm**; gamma chlordane ranged from 5.9 to 7.9ppm with an average of **6.8ppm**; methoxychlor ranged from 1.3 to 1.4ppm with an average of **1.4ppm**, and toxaphene ranged from 4.3 to 5.0ppm with an average of **4.7ppm**.



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The pesticide data at 6 weeks are shown in Table 3

Analyses performed by US EPA Region 4 Lab, Athens, GA

Table 3: Pesticide concentrations after 6 weeks of Factor Treatment. Sampled on Dec 8, 2011.

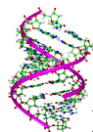
| Sample | Alpha Chlordane mg/Kg | Dieldrin mg/Kg | Gamma Chlordane mg/Kg | Methoxychlor mg/Kg | Toxaphene mg/Kg |
|---------------------|--------------------------|-------------------|--------------------------|-----------------------|--------------------|
| WFC1-6 (control) | 4.2 | 1.0 | 5.6 | 0.3 | 4.8 |
| WFC2-6 | 2.9 | 0.8 | 3.8 | 0.4 | 2.8 |
| WFC3-6 | 3.5 | 0.9 | 4.6 | 0.4 | 2.7 |
| WFC4-6 | 3.3 | 0.9 | 4.3 | 0.4 | 2.8 |
| WFC5-6 | 3.4 | 0.8 | 4.4 | 0.4 | 3.2 |
| WFC6-6 | 3.2 | 0.8 | 4.2 | 0.4 | 2.7 |

All other pesticides in treated samples were present at < 0.5 mg/Kg

Table 4 uses the same raw data as Table 3, but expresses the results as percent reduction of each contaminant compared to the initial value at 0 weeks for each individual container.

Table 4: Percent reduction in pesticide concentrations after 6 weeks of Factor Treatment

| Sample | Alpha Chlordane % reduction | Dieldrin % reduction | Gamma Chlordane % reduction | Methoxychlor % reduction | Toxaphene % reduction |
|---------------------|--------------------------------|-------------------------|--------------------------------|-----------------------------|--------------------------|
| WFC1-6 (control) | 14 | 17 | 14 | 77 | 0 |
| WFC2-6 | 34 | 33 | 36 | 69 | 40 |
| WFC3-6 | 41 | 25 | 42 | 71 | 41 |
| WFC4-6 | 27 | 10 | 28 | 71 | 35 |
| WFC5-6 | 39 | 33 | 41 | 71 | 36 |
| WFC6-6 | 40 | 20 | 41 | 71 | 43 |



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Tables 5 and 6 show the pesticide results obtained after 10 weeks of Factor Treatment.

Table 5: Pesticide concentrations after 10 weeks of Factor Treatment. Sampled on January 5, 2012

| Sample | Alpha Chlordane mg/Kg | Dieldrin mg/Kg | Gamma Chlordane mg/Kg | Methoxychlor mg/Kg | Toxaphene mg/Kg |
|----------------------|--------------------------|-------------------|--------------------------|-----------------------|--------------------|
| WFC1-10 (control) | 5.2 | 1.6 | 6.7 | 0.3 | 6.9 |
| WFC2-10 | 2.3 | 0.7 | 3.0 | 0.4 | 2.6 |
| WFC3-10 | 0.9 | 0.3 | 1.1 | 0.4 | 0.9 |
| WFC4-10 | 1.4 | 0.5 | 1.9 | 0.4 | 1.6 |
| WFC5-10 | 4.1 | 1.2 | 5.4 | 0.4 | 4.2 |
| WFC6-10 | 3.5 | 1.2 | 4.7 | 0.4 | 4.3 |

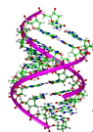
All other pesticides in treated samples were present in concentrations of < 0.9mg/Kg

Table 6: Percent reduction in pesticide concentrations after 10 weeks of Factor Treatment

| Sample | Alpha Chlordane % reduction | Dieldrin % reduction | Gamma Chlordane % reduction | Methoxychlor % reduction | Toxaphene % reduction |
|----------------------|--------------------------------|-------------------------|--------------------------------|-----------------------------|--------------------------|
| WFC1-10 (control) | 0 | 0 | 0 | 77 | 0 |
| WFC2-10 | 48 | 42 | 49 | 69 | 45 |
| WFC3-10 | 85 | 75 | 86 | 71 | 80 |
| WFC4-10 | 69 | 50 | 68 | 71 | 63 |
| WFC5-10 | 27 | 0 | 28 | 71 | 16 |
| WFC6-10 | 34 | 0 | 34 | 71 | 9 |

The highlighted rows in Tables 5 and 6 indicate both by their values in Table 5 and the % reduction in Table 6 that the Factors used in experimental containers 3 and 4 are the most effective in reducing the pesticide concentrations over this 10 week period. The concentrations of alpha chlordane, gamma chlordane, methoxychlor and toxaphene are already below the clean up levels for commercial use.

The final sampling took place after 16 weeks of Factor Treatment; however, by this time there was insufficient soil left in most of the containers to obtain a representative sample, and none left in container WFC6 as an additional sample was required from this container at 10 weeks for extra quality control studies. The Factor treatment had already been initiated before BTR was notified that they would be carrying out the analysis of the toxaphene congeners, and congener analysis would require additional soil at each of the remaining sample dates of 6, 10, and 16 weeks. In future bench studies where congener testing is anticipated, a greater initial volume of soil will be collected to eliminate the possibility of depleting the test containers and the need to collect samples from the sidewalls of the containers.



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The results for the pesticide analysis are shown in Table 7, but were not included in the decision of Factor selection for reasons outlined above.

Table 7: Pesticide concentrations after 16 weeks of Factor Treatment. Sampled on February 15, 2012

| Sample | Alpha Chlordane mg/Kg | Dieldrin mg/Kg | Gamma Chlordane mg/Kg | Methoxychlor mg/Kg | Toxaphene mg/Kg |
|-------------------|-----------------------|----------------|-----------------------|--------------------|-----------------|
| WFC1-16 (control) | 5.3 | 1.5 | 7.0 | 0.3 | 7.6 |
| WFC2-16 | 3.4 | 1.1 | 4.4 | 0.4 | 3.9 |
| WFC3-16 | 3.7 | 1.4 | 4.9 | 0.4 | 4.1 |
| WFC4-16 | 4.2 | 1.3 | 5.7 | 0.4 | 3.5 |
| WFC5-16 | 3.1 | 0.1 | 4.1 | 0.4 | 3.3 |
| WFC6-16* | - | - | - | - | - |

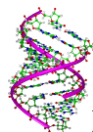
* No soil available for sampling

All other pesticides were present at <0.8mg/Kg except for DDT at 2.9mg/Kg in sample WFC3-16

The results for the toxaphene congeners are shown in tables 8 - 13. Samples for the analysis of toxaphene congeners were taken at the same time and from the same experimental containers as the samples for the pesticide analysis at 6, 10 and 16 weeks, and shipped to the US EPA Region 4 Lab at Athens, GA for extraction and analysis by negative ion mass spectroscopy. Since no analysis was performed at 0 weeks, the values for the toxaphene congeners of the control (WFC1) to which nothing had been added (no water, amendments or Factors) was used as the initial concentrations of each of the congeners to which the values obtained for the Factor treated samples (WFC2 to WFC6) were compared.

Table 8: Toxaphene congener concentrations after 6 weeks of Factor Treatment. Sampled on December 8, 2011

| Sample | Hp-Sed ug/Kg | Hx-Sed ug/Kg | Tox. Parlar 26 ug/Kg | Tox. Parlar 40 ug/Kg | Tox. Parlar 41 ug/Kg | Tox. Parlar 44 ug/Kg | Tox. Parlar 50 ug/Kg | Tox. Parlar 62 ug/Kg |
|------------------|--------------|--------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| WFC1-6 (control) | 870 | 280 | 110 | 150 | 32 | 32 | 48 | 51 |
| WFC2-6 | 350 | 120 | 35 | 55 | 16 | 18 | 26 | 31 |
| WFC3-6 | 350 | 120 | 32 | 51 | 12 | 13 | 18 | 15 |
| WFC4-6 | 390 | 130 | 40 | 62 | 17 | 19 | 25 | 19 |
| WFC5-6 | 290 | 100 | 30 | 47 | 13 | 16 | 23 | 27 |
| WFC6-6 | 360 | 120 | 38 | 61 | 17 | 20 | 27 | 21 |



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Table 9: Percent reduction in toxaphene congener concentrations after 6 weeks of Factor Treatment

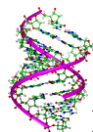
| Sample | Hp-Sed % Rdn* | Hx-Sed % Rdn | Tox, Parlar 26 % Rdn | Tox, Parlar 40 % Rdn | Tox, Parlar 41 % Rdn | Tox, Parlar 44 % Rdn | Tox, Parlar 50 % Rdn | Tox, Parlar 62 % Rdn |
|--------|---------------------|--------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| WFC2-6 | 60 | 57 | 68 | 63 | 50 | 44 | 46 | 39 |
| WFC3-6 | 60 | 57 | 71 | 66 | 63 | 59 | 63 | 71 |
| WFC4-6 | 55 | 54 | 64 | 59 | 47 | 41 | 48 | 63 |
| WFC5-6 | 67 | 64 | 73 | 69 | 59 | 50 | 52 | 47 |
| WFC6-6 | 59 | 57 | 65 | 59 | 47 | 38 | 44 | 59 |

* % Rdn = percent reduction

Tables 10 and 11 show the concentrations of the congeners and the % reduction respectively after 10 weeks of Factor Treatment.

Table 10: Toxaphene congener concentrations after 10 weeks of Factor Treatment. Sampled on January 5, 2012

| Sample | Hp-Sed ug/Kg | Hx-Sed ug/Kg | Tox. Parlar 26 ug/Kg | Tox. Parlar 40 ug/Kg | Tox. Parlar 41 ug/Kg | Tox. Parlar 44 ug/Kg | Tox. Parlar 50 ug/Kg | Tox. Parlar 62 ug/Kg |
|--------------------|-----------------|-----------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| WFC1-6-10(control) | 430 | 130 | 45 | 68 | 20 | 22 | 35 | 31 |
| WFC2-10 | 220 | 75 | 22 | 36 | 9.8 | 11 | 16 | 12 |
| WFC3-10 | 320 | 110 | 26 | 43 | 9.5 | 11 | 15 | 13 |
| WFC4-10 | 300 | 100 | 27 | 43 | 10 | 9.1 | 10 | 9.1 |
| WFC5-10 | 240 | 79 | 24 | 40 | 11 | 12 | 19 | 16 |
| WFC6-10 | 260 | 91 | 26 | 42 | 11 | 13 | 18 | 13 |



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Table 11: Percent reduction in toxaphene congener concentrations after 10 weeks of Factor Treatment.

| Sample | Hp-Sed % Rdn* | Hx-Sed % Rdn | Tox, Parlar 26 % Rdn | Tox, Parlar 40 % Rdn | Tox, Parlar 41 % Rdn | Tox, Parlar 44 % Rdn | Tox, Parlar 50 % Rdn | Tox, Parlar 62 % Rdn |
|----------------------|---------------------|--------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| WFC1-10 (control) | 51 | 54 | 59 | 55 | 38 | 31 | 27 | 39 |
| WFC2-10 | 75 | 73 | 80 | 76 | 69 | 66 | 67 | 76 |
| WFC3-10 | 63 | 61 | 76 | 71 | 70 | 66 | 69 | 75 |
| WFC4-10 | 66 | 64 | 75 | 71 | 69 | 72 | 79 | 82 |
| WFC5-10 | 72 | 72 | 78 | 73 | 66 | 63 | 60 | 69 |
| WFC6-10 | 70 | 68 | 76 | 72 | 66 | 59 | 63 | 75 |

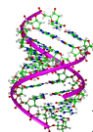
* % Rdn = percent reduction

The results of toxaphene congener concentrations after 16 weeks of Factor Treatment are shown in Tables 12 and 13

Table 12: Toxaphene congener concentrations after 16 weeks of Factor Treatment. Sampled February 15, 2012

| Sample | Hp-Sed ug/Kg | Hx-Sed ug/Kg | Tox, Parlar 26 ug/Kg | Tox, Parlar 40 ug/Kg | Tox, Parlar 41 ug/Kg | Tox, Parlar 44 ug/Kg | Tox, Parlar 50 ug/Kg | Tox, Parlar 62 ug/Kg |
|----------------------|-----------------|-----------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| WFC1-16 (control) | 430 | 140 | 51 | 82 | 23 | 26 | 44 | 41 |
| WFC2-16 | 280 | 94 | 27 | 44 | 12 | 13 | 20 | 14 |
| WFC3-16 | 280 | 97 | 23 | 37 | 7.9 | 9.3 | 13 | 9.4 |
| WFC4-16 | 300 | 110 | 26 | 42 | 8.8 | 7.4 | 6.9 | 7.7 |
| WFC5-16 | 250 | 85 | 25 | 40 | 12 | 13 | 19 | 16 |
| WFC6-16* | - | - | - | - | - | - | - | - |

* No soil available for testing



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Table 13: Percent reduction in toxaphene congener concentrations after 16 weeks of Factor Treatment

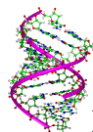
| Sample | Hp-Sed % Rdn** | Hx-Sed % Rdn | Tox, Parlar 26 % Rdn | Tox, Parlar 40 % Rdn | Tox, Parlar 41 % Rdn | Tox, Parlar 44 % Rdn | Tox, Parlar 50 % Rdn | Tox, Parlar 62 % Rdn |
|----------------------|----------------------|--------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| WFC1-16 (control) | 50 | 50 | 54 | 45 | 28 | 19 | 8 | 39 |
| WFC2-16 | 68 | 66 | 68 | 71 | 63 | 59 | 58 | 73 |
| WFC3-16 | 68 | 65 | 79 | 75 | 75 | 71 | 73 | 82 |
| WFC4-16 | 66 | 61 | 76 | 72 | 73 | 77 | 86 | 85 |
| WFC5-16 | 71 | 70 | 77 | 69 | 63 | 59 | 60 | 69 |
| WFC6-16 | - | - | - | - | - | - | - | - |

* No soil available for testing

** % Rdn = percent reduction

It appears that Factors applied to experimental containers WFC3 and WFC4 have had the most effect in reducing the concentration of the toxaphene congeners.

Conclusions: The purpose of this bench study was to identify a Factor or Factors capable of reducing the concentrations of pesticides as well as the toxaphene congeners present in the soil at the Woolfolk Chemical site. During any Factor bench study, the goal is not to reduce contamination levels to non-detect, the goal is to identify the most effective Factors to achieve the site's desired clean-up. The data indicates the bench study has been successful in achieving this goal. The decrease in pesticide levels at 6 and 10 weeks indicates that the bioremediation is following the same reductive pattern observed in other Factor based treatments of pesticide impacted soils. There is a high degree of confidence that this bench study has identified an effective Factor formulation for the treatment of pesticide impacted soils at the Woolfolk Chemical site. The principals of Biotech Restorations are pleased to have been able to demonstrate by analytical method and in cooperation with EPA Region IV that a Factor remedy is able to reduce the concentrations of the target pesticides below EPA's mandated clean up goals while concurrently reducing the toxaphene congeners by as much as 85%.



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Respectfully submitted,
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Valerie A. Paynter and Christopher W. Young